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(54) Heating cable and method producing the same

(57) The present invention relates to a heating cable comprising a core having two electrical conductors (4,5), a PTC element therebetween and an outer layer (3) of insulation material. The core comprises an extruded polymer center element (1) in which the two conductors (4,5) are arranged so that part of the conductor surfaces coincide with the center element surface, an extruded layer (2) of a PTC polymer arranged over the center element in contact with said conductor surface parts, and at least one outer extruded insulation sheath (3). The PTC layer (2) is based on ethylene and ethylene-octene copolymer with carbon black and silane grafted by direct feeding silane/peroxide or using a Master Batch with silane/peroxide/catalyst.

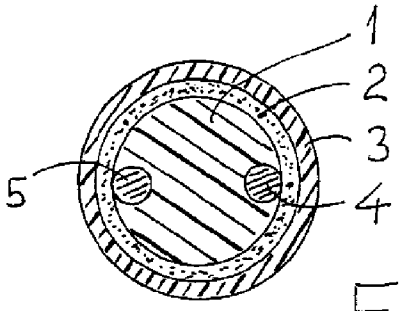

Fig. 1

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Description

The present invention relates to electrical heating cables and in particular to heating cables of the selfregulating type. Such cables include two electrical conductors or electrodes and a PTC (Positive Temperature Coefficient) element arranged between the conductors. When the two conductors are connected to a current source, current will flow from one conductor to the other through the PTC material and generate controlled heat.

Such cables are generally known from EP 0 160 100 A1 which describes a PTC heating cable having a cord- or tape-like structure. A PTC heating element is provided between a pair of electrodes and the outer periphery of these members is covered with an insulation sheath. A mathematical formula is determined for setting the resistance value of the electrodes.

A selflimiting electrical heating device using a PTC element between two conductors is also known from SE 433 999. The PTC effect is obtained with a certain composition of materials. A defined gap or distance between the two conductors is maintained by means of a special distance element or by incorporating glass fiber material in the PTC element.

The object of the present invention is to improve the quality of selfregulating heating cables. This is obtained by making a new cable design and by simplifying the manufacturing method. The main features of the invention are defined in the claims.

The present invention also relates to methods and means for crosslinking the PTC and other polymers used in the cable. This has previously been done with irradiation technique, but such processes should be avoided. The silane crosslinking process can be undertaken by means of water and steam at a temperature of 20-100 °C.

With this invention we have obtained a manufacturing process by which the cable can be produced in a cost effective way, - resulting in a heating cable with stable PTC properties.

Above mentioned and other features and objects of the present invention will clearly appear from the following detailed description of embodiments of the invention taken in conjunction with the drawings, where

Figure 1 schematically shows a crossection of the cable, and

Figures 2 to 4 illustrate process lines for manufacturing the cable.

In Figure 1 is indicated a laminated cable structure consisting of a center element 1, a semiconducting layer 2 and outer insulation 3. This polymer laminate is crosslinked by means of a silane process. Outer protecting sheaths (not shown) could consist of a metal sheath/layer and an outer corrosion protective layer of halogen free compound, PVC or Teflon. The illustration shows a circular crossection and is not drawn to scale. The crossection may alternatively be oval or flattened in other ways. The center element 1 and the insulation 3 may consist of polyethylene with silane/peroxide/antioxidant. The semiconducting layer 2 may consist of polyethylene/ethylene-octene/ethylene/spherelene, carbon black, silane/peroxide/antioxidant.

Two bare conductors 4 and 5 - of copper or other suitable material - are tangentially arranged in the center element 1 so that part of the conductor surfaces coincide with the surface of the center element. The conductors should preferably be arranged in opposite sides of the center element as illustrated. The PTC layer 2 is arranged over the center element in contact with said conductor surface parts. When the conductors 4 and 5 are connected to a current source, - current will flow through the concentrical PTC layer from one conductor to the other and generate controlled heat in the cable.

The cable core elements 1-5 may be assembled in a manufacturing line as illustrated in Figure 2 to provide the cable core illustrated in Figure 1. The line may include a number of polymer extruders arranged in tandem to provide a core which in a further process is spirallized and then crosslinked in order to lock the spirallization and bond the layers together.

In Figure 2 the center element 1 is supplied from an extruder 10. The conductors 4 and 5 are supplied from reels 11 and 12 to a die 13 where the conductors are inserted into corresponding slots of the center element 1. The resulting core element 14 is passed through an extruder 15 for application of the PTC layer 2 and further through an extruder 16 for application of the insulation sheath 3 to produce the core 17. The extruders 15 and 16 could be a two layer extruder. This core 17 is wound on a reel 18 which is also rotated in a plane perpendicular to the line axis to give the core a desired spirallization on the reel. Finally - and before application of the outer protective layers (not shown) - the polymer materials of the core are crosslinked in a silane crosslinking process (not shown) whereby the spirallization is locked.

Alternatively to the first part of the process of Figure 2, the conductors 4 and 5 can be supplied from their reel directly into a center element extruder 20, Figure 3, for providing the core 14 which is passed through extruders 15/16 and further processing.

Alternatively to the process illustrated in Figures 2 and 3, the cable core can be assembled in a number of consecutive steps as illustrated in Figure 4. The elements 1+4+5 can be assembled in a first extruding process as outlined and the core 14 can be wound on a reel 30. In further processing the center element reel 30 can be rotated in a plane perpendicular to the line axis to give the element 14 a desired spirallization before passing it through extruders 15 and 16 to produce a core 31 which is similar to the core 17 but which has a spirallized center element. This core is wound on a reel 32 for silane crosslinking and further processing.

Still alternatively the center element 1 can be pre-

made with slots and spirallized and then crosslinked before inserting the conductors 4 and 5 into the slots and passing this cable core 1+4+5 through extruders 15-16 and further silane crosslinking means.

The spirallization is required in order to obtain a flexible cable which easily lends itself to installation in floors for room heating. Instead of a helical configuration the center element slots and conductors could have a wiggle-waggle (S-Z) form.

The present invention use polymer based on metallocene technology and has to be grafted and crosslinked with the silane process.

The center element 1 consists of silane crosslinked polyethylene. The polyethylene includes molecules of vinyltrimethoxysilane containing an organo heavy metal compound in an amount of from 0.005 to 1% by weight based on the total amount of said composition as a crosslinking catalyst.

The PTC polymer layer 2 is based on ethylene and ethylene-octene copolymer with carbon black and silane grafted by direct feeding silane/peroxide or using a Master Batch (MB) containing components which are needed to crosslink and heat stabilize the polymer materials involved in a silane/peroxide/catalyst process.

The PTC layer 2 and the insulation layer 3 are crosslinked by cross-linking reaction of trimethoxsilane groups in said polyethylene and the PTC polymer in the presence of water.

The PTC layer 2 and the insulation layer 3 may as mentioned above be extruded in one process and the PTC layer contains an organo metal compound selected from the group consisting of dibutyltin dilaurate. The insulation layer 3 may be cured or crosslinked, by diffusion of the catalyst agent-dibutyltin dilaurate - from the PTC layer.

The above detailed description of embodiments of this invention must be taken as examples only and should not be considered as limitations on the scope of protection.

Claims

1. Heating cable comprising a core having two electrical conductors (4,5), a PTC element therebetween and an outer layer (3) of insulation material,
characterized in that
the core comprises an extruded polymer center element (1) in which the two conductors (4,5) are arranged so that part of the conductor surfaces coincide with the center element surface, an extruded layer (2) of a PTC polymer arranged over the center element in contact with said conductor surface parts, and at least one outer extruded insulation sheath (3).

2. Cable according to claim 1,
characterized in that
the conductors (4,5) are spirallized or wiggle-waggled (S-Z) in the center element.

3. Cable according to claim 1,
characterized in that
at least two of the extruded polymer elements of the cable core -the center element (1) and the two layers (2,3) - are bonded together.

4. Cable according to claim 1,
characterized in that
the polymer elements (1;2;3) of the cable core are crosslinked with a silane process.

5. Cable according to claim 1,
characterized in that
the center element (1) consists of silane crosslinked polyethylene including molecules of vinyltrimethoxysilane containing an organo heavy metal compound in an amount of from 0.005 to 1% by weight based on the total amount of said composition as a crosslinking catalyst.

6. Cable according to claim 1,
characterized in that
the PTC layer (2) is based on ethylene and ethylene-octene copolymer with carbon black and silane grafted by direct feeding silane/peroxide or using a Master Batch with silane/peroxide/catalyst.

7. Cable according to claim 1,
characterized in that
the PTC layer (3) has a volume resistivity of 100 -100 000 ohmcm.

8. Method for making a heating cable comprising a core having two electrical conductors (4,5), a PTC element therebetween and an outer layer (3) of insulation material,
characterized by
crosslinking the PTC element (2) and the insulation layer (3) using reaction of trimethoxsilane groups in the polyethylene and in the PTC polymer in the presence of water.

9. Method according to claim 1,
characterized by
including in the PTC layer (2) an organo metal compound selected from the group consisting of dibutyltin dilaurate.

10. Method according to claim 9, and where the PTC layer (2) and the insulation layer (3) are extruded in one process, **characterized by** curing or crosslinking the insulation layer (3) by diffusion of the catalyst agent-dibutyltin dilaurate - from the PTC layer.

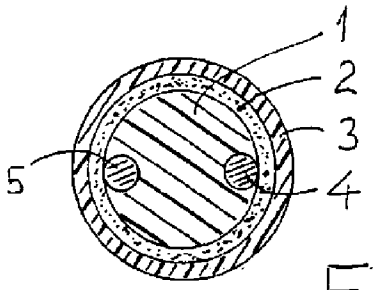

Fig. 1

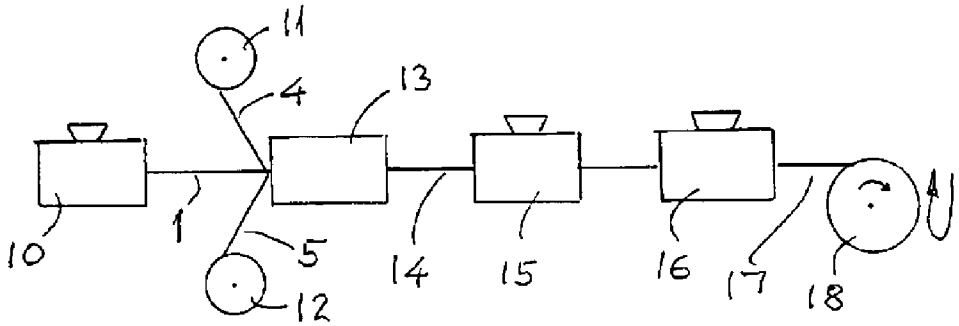

Fig. 2

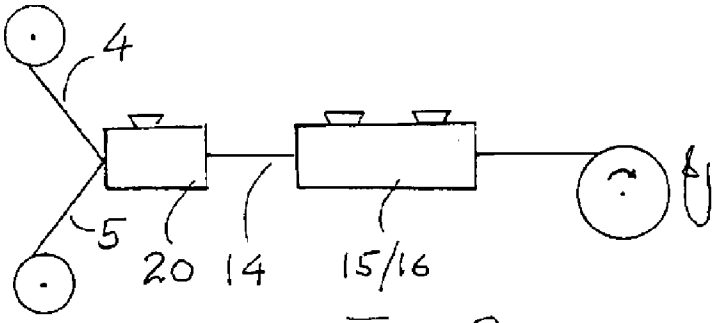

Fig. 3

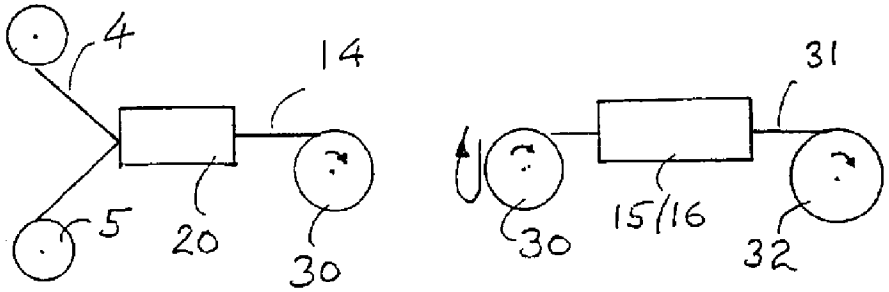

Fig. 4

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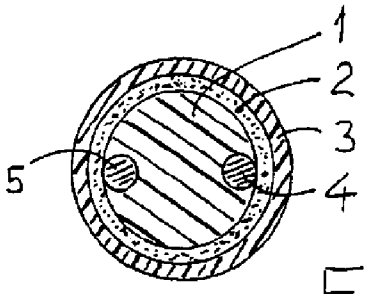

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 98 40 0785

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 April 1999	Wansing, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 40 0785

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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